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HUMAN FACTORS PROBLEMS IN ANTI-SUBMARINE WARFARE

TECHNICAL MEMORANDUM 206-18

NOTES ON SOME HUMAN FACTORS PROBLEMS IN FIXED WING ASW (U)

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Technical Memorandum 206-18

NOTES ON SOME HUMAN FACTORS PROBLEMS IN FIXED WING ASW (U)

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NOTES ON SOME HUMAN FACTORS PROBLEMS IN FIXED WING ASW

Introduction

While the concept of fixed wing ASW has a history extending back to War II, during the ensuing years the associated equipment has undergone, and is still undergoing, continuous changes aimed at improving system efficiency. New equipment has typically resulted in new tactical techniques and, of course, in new programs aimed at training operating and maintenance personnel. Without known exception, however, during the past 17 years the problems which can be subsumed under the heading of "Human Factors" have been largely ignored. The policy appears to have been that an operator is a constant, a simple switch to close the loop, invariant in various visual and acoustic environments, invariant in time on watch, but gradually improving with increasing "experience." The notion that "an operator is an operator," i.e., a constant, is, of course, complete nonsense. The notion that he improves with "experience" is also nonsense, unless the experience is deliberately planned to provide thorough feedback concerning errors in performance, and not always then.

It would be a hazardous task to estimate the cost in fixed wing ASW efficiency consequent to the continual neglect of human factors problems; indeed, it may be relatively slight. On the other hand, it would be very difficult to demonstrate that all the "improvements" in equipment have resulted in detection, localization, and killing efficiency superior to that which prevailed 17 years ago.

These notes are based upon a very brief survey of the activities of FAW 14 and a few associated units. The survey was made at the

invitation of the Commander, FAW 14. The aim of the survey was to determine what human factors problems existed, if any, and to point them out. (The survey was certainly far from being detailed or exhaustive, hence the use of the term "some" in the title.) The problems are considered under the general headings of Equipment, Training, and Personnel. In some cases immediate solutions are apparent, in others the solutions would require detailed analyses, while in still others experimental research is indicated. The fact that there are numerous human factors problems is not to be construed as reflecting on the ability of any of the military personnel involved. All the problems appear to have been inherited.

As a final introductory note we must point out that the primary peacetime mission of FAW 14 (and presumably of all similar wings) is the maintenance of a high degree of readiness for and skill in the task of detecting, localizing, and killing submarines. Routine patrol activity is a subsidiary mission. The demands made upon the airborne crews if adequate performance is to be the norm are, to say the very least, exacting. The difficulties with respect to inadequate sensing devices, poor displays, and long periods on watch are compounded by the fact that the operational squadrons, even when flying, are attempting to train. In other words they are <u>not</u> operational squadrons, but <u>operational-training</u> squadrons.

Problems Associated With The Equipment In General

There are a number of equipment problems in the P5M and P2V which are "built-in" and must be lived with. For example, from the human engineering point of view the design of most of the ASW consoles is atrocious and if it could serve any purpose we would be able to specify some 50 or so errors in design. The inevitable consequence of such poor design is longer training to reach a specified standard and (not "or") increased probability of error

on the part of the operator during times of peak pressure. (Interestingly, such errors are almost invariably termed "human errors," "human" referring to the operator rather than to the designer.)

Other problems, too, appear to be "built-in." For instance, in view of the considerable amount of empty space in the P5M we would be extremely interested to know the considerations responsible for the decision to have all equipment operators cramped together on the flight deck, particularly as all communications are by ICS. The consequent lack of a writing surface on which to keep necessary logs, the inability to cross knees under the consoles, severely high temperatures on occasion, and the difficulty of getting in or out of the seats all combine to produce, during long routine flights, a degree of discomfort which must detract from the efficiency with which the main task in hand might otherwise be performed. In some of these aircraft the crewmen in the waist do not even have a seat. Finally, in view of the fact that visual search is still valued as a technique for detection (apparently including the detection of engine fires at night), it is most surprising to find, in some aircraft, no stations expressly designed to permit visual search to each side. Because of the nature of visual search the rear bubble <u>cannot</u> be considered adequate for search to each side--(even if the bubble surface is clean!).

Problems Concerning The Radar

The primary role of the radar is to provide initial detection of snorkels or periscopes. A periscope, if displayed at all, would be extremely small and possibly indistinguishable in size from the average noise spot; indeed, of the dozen or so operational personnel queried, none had ever seen a pip generated by a periscope.* This

*Nor is a simulated periscope pip available. The smallest pips generated on the radar displays in the Weapon Systems Trainers are meant to represent snorkels.

perceptual problem is difficult, <u>even if the operator is alerted</u>, which will be seldom. At the same time it can be expected that initial detections, particularly at night, will be made predominantly by radar. Such being the case <u>every effort</u> should be made to ensure that the operating conditions are optimum.

<u>Radar Display Brightness</u>

It is generally not recognized that radar display brightness is an <u>extremely</u> important factor in rendering a target visible. Display brightness, which is varied by the brilliance control, is determined by the bias voltage on the grid of the CRT, and by noise. As bias increases brightness decreases. At high biases (low brightnesses) the voltage generating the pip must be considerable in order to be seen. On the other hand, radar display phosphors tend to saturate if brightness is too great. This situation implies an intermediate brightness setting to maximize the probability that a pip will be visually detected: when this setting is made a condition of optimum display brightness prevails.

Figure 1 shows how pip visibility varies with variations in display brightness. Visibility is given in decibels. At a bias of about -17 volts this particular display was at optimum brightness. The term Visual Reference Intensity (VRI) at -22 volts refers to a brightness at which the rotating sweep-line was just visible, a brightness which is common in many operational settings. The loss consequent to working at this brightness rather than at optimum is enormous, being more than 15 decibels (13).

The decibel values in Figure 1 have been translated into percentage of maximum range obtainable with variations in display brightness. Here optimum display brightness is credited with maximum range performance and it can be seen that operating near

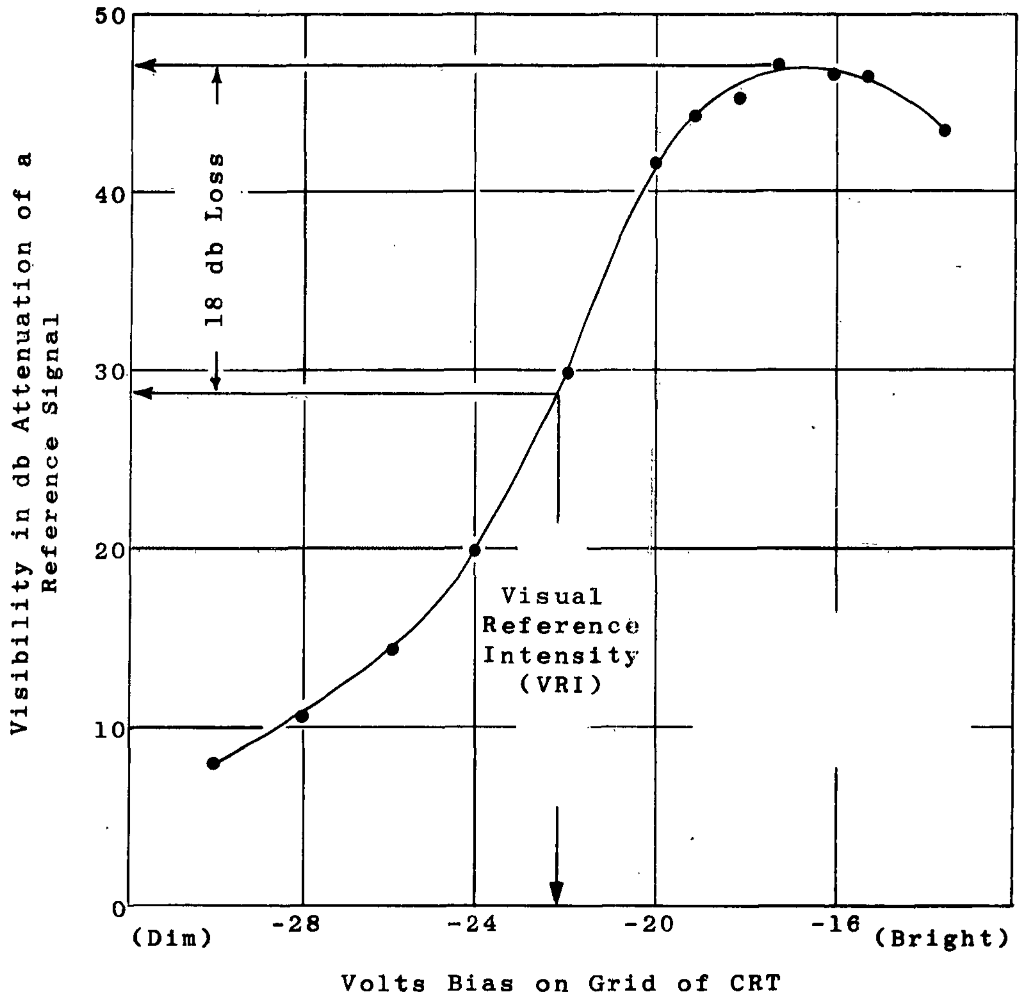

Figure 1. The relation of the pip visibility threshold to scope brightness.

VRI involves a loss of 40 per cent in range*, which is about 65 per cent in possible radar coverage--see Figure 2 (12).

These results from laboratory studies led to a controlled experiment on an operational site, with the result that: (a) 19 per cent more track-plot points were recorded in the compartment operating at optimum display brightness than in that operating at VRI; (b) of 70 targets tracked for 20 or more miles using optimum brightness, 3 were never recorded when operating at VRI, 10 were recorded as one plot only, and 18 were tracked for less than 20 miles; (c) using optimum brightness, targets were tracked farther in 43 cases; and (d) the average range of initial detection with optimum brightness was greater by 34 miles than that when operating at VRI (2). It is our impression that the radar in the P5M is generally operated at a non-optimum brightness.

Illumination at the Radar Display

Considerable experimental work has established that with the P19 phosphor (which is used in the P5M radar display) the tolerable amount of ambient illumination is 0.5 foot-candle. An effective loss of 4 decibels is sustained when the illumination is increased to just 1.0 foot-candle (10). During daylight flight in the P5M the ambient illumination at the radar display is constantly changing and sometimes it is well in excess of 1.0 foot-candle.

In this connection it should be noted that if the radar operator exposes his eyes to daylight-sky brightness for any appreciable period of time, his ability to detect a pip upon again

*It will be realized that when a radar (or sonar) is set to operate at, say, the 20-mile range scale, there is no guarantee that it is in fact doing so. It will be further realized that a target which generates a marginally visible pip at half-range, 10 miles, will probably not generate a pip if the range is slightly greater.

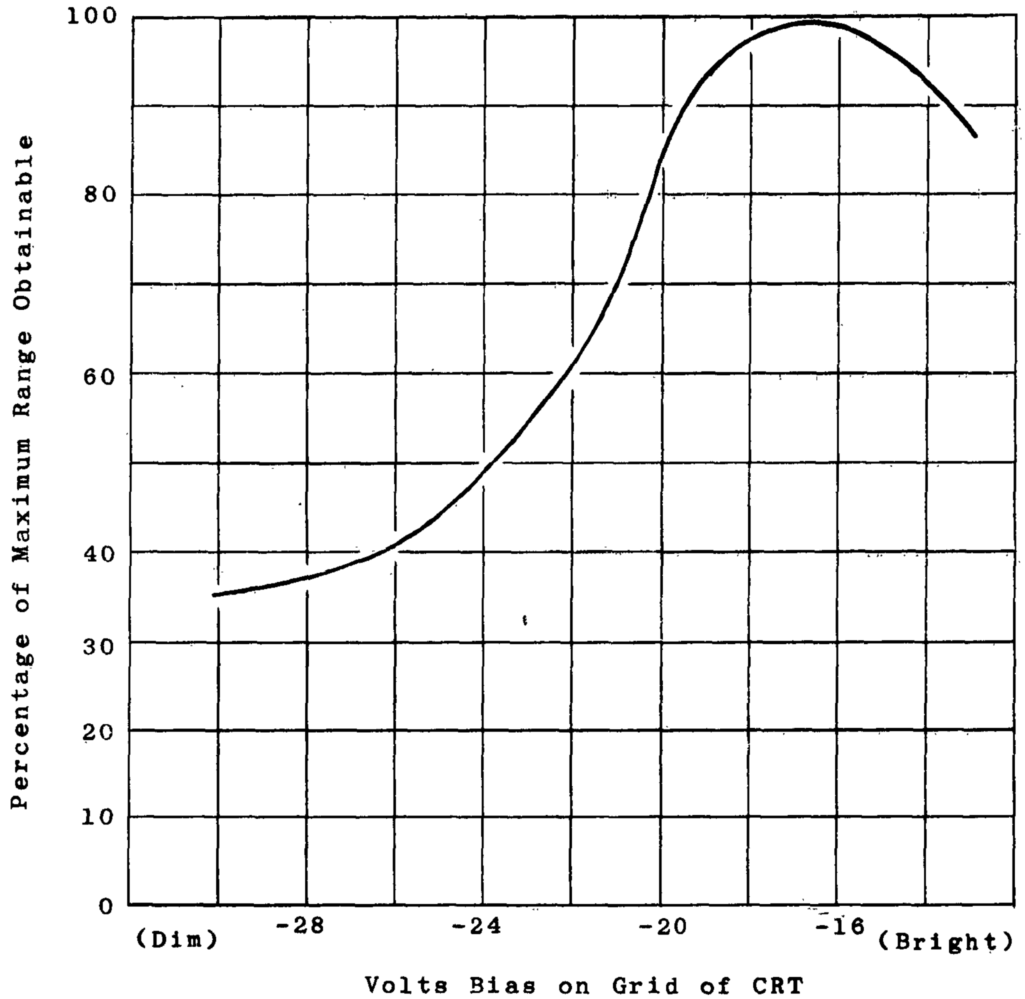

Figure 2. Percentage of maximum range obtainable as a function of scope brightness.

glancing at the display is <u>very</u> seriously hampered. If, for example, he gazes out of a nearby window for 5 minutes, a pip must be 20 or even more decibels above that brightness which he can just detect when he is properly adapted, if the pip is to be seen immediately (5).

Problems Concerning JEZEBEL And MAD

With respect to local illumination, the enclosed lighting unit for JEZEBEL traces should be studied. It will be obvious that with very low illumination some JEZEBEL traces will be invisible. On the other hand, too much light will create a glare condition which could also render some traces invisible. This situation implies an optimum level of illumination and there is no evidence to suggest that the current system is providing the optimum. The current system is certainly faulty in one respect as it is uneven.

Another feature of the JEZEBEL display concerns the degree of slant. The purpose of the slant is to allow the operator's visual system to integrate the contrast of trace vs. noise background. The degree of visual integration must vary with various degrees of slant, or, at the slant now employed, with various viewing angles. With just perceptible traces viewing angle will be critical and the correct angle should be determined and a simple aid devised to indicate to the operator just where he should view from.

With regard to MAD, the following quotation from a report by Human Factors Research, Inc., some 6 years ago, is pertinent:

> "The sensitivity of the MAD equipment necessitates extreme care in the interpretation of traces. Sufficient geological and electrical noise peaks occur to make it extremely easy to get a target when one is strongly expected, such as after spotting a snorkel or

> a disappearing radar contact. Many of the traces observed by project personnel indicated poorly peaked equipments and the numerous MAD "gripes" indicate that...the maintenance problem [is] a large one." (4)

Our current impression is that the situation today differs not a whit from that described above. What should the paper speed be? How should the gain be set? What is the probability that an excursion of a certain amplitude will be wrongly identified as a submarine, or wrongly classified as "non-target?" The answers to these and other questions should have been determined years ago. None are known, even today, but they could be after a relatively short experimental investigation. (The same is true, of course, of JULIE.)

Again with respect to the above quotation, the last 45 minutes of a recent MAD "exercise" with a snorkeling submarine consisted of making a number of low passes over the target. The operator's job was to report "contact" when the MAD gear sensed the sub. The operator didn't merely "strongly suspect" a contact, he <u>knew</u> the submarine was about to be flown over on every pass, and, indeed, he made "contact" on nearly every pass. Two questions can be raised here. First, it is not known whether all contacts were genuinely made, as reported, since the traces were not subsequently examined--the "expectancy" factor may have accounted for several of them; and second, it is not known what reports would have been made had some of the legs flown been <u>not</u> over the sub. Both training and system capability could have been better evaluated had half of the legs been flown directly over the sub and half purposely <u>not</u> over the sub, in random order, without the operator's knowledge of which was which. From an exercise of this proposed type, the reports of "contact" and "no contact" would have given a definite indication of whether the MAD gear and operator were working effectively or

not.* Though there was an apparent delusion that they were in the exercise observed, such "proof" is far from convincing and, if incorrect, grossly misleading.**

Possibilities Of Simple Equipment Modification

There are a few equipment problems that could be reduced appreciably by the application of very simple human engineering principles. As an example, it is reported that the JULIE operator, after setting his A and B cursors, occasionally reads the wrong digital range readout, e.g., for cursor setting A he reads range readout B. The consequence is, of course, a serious error in localization.

In Figure 3 the current design is shown, along with a proposal involving the use of color coding. If this simple proposal were instituted, there should be a significant reduction in such errors. Because night operations involve the use of low level red illumination on the flight deck, the colors should be self luminous:

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*All ASW exercises should be planned so that the element of doubt becomes a factor to be resolved. Is a non-submarine deflection invariably reported as a submarine or, somewhere during the exercise, does one of the operators classify it correctly as a fishing boat? The operators should be kept in ignorance, of course, until the correct classification is given. Routine tactical procedures could proceed as if it really were a submarine. In addition to conducting exercises which are much more similar to what might be expected in active operations, training would be considerably enhanced, and much more "sub" time would be available.

**It is pertinent here to refer to another early report by Human Factors Research, Inc. (7). The results of a fleet exercise (alerted operators) held in 1954 were described as follows: Of 60 contacts classified submarine on MAD gear (VS aircraft), 11 were submarines--18% correct. Of 7 contacts classified as submarines on sonobuoys, only 2 could have been submarines--28% correct. Of 111 ECM contacts by VS, VP and ZP aircraft, none was an opposing submarine--0% success. Of 1250 exposures of periscopes, snorkels, radar masts, 12 valid radar contacts were made--1% success.

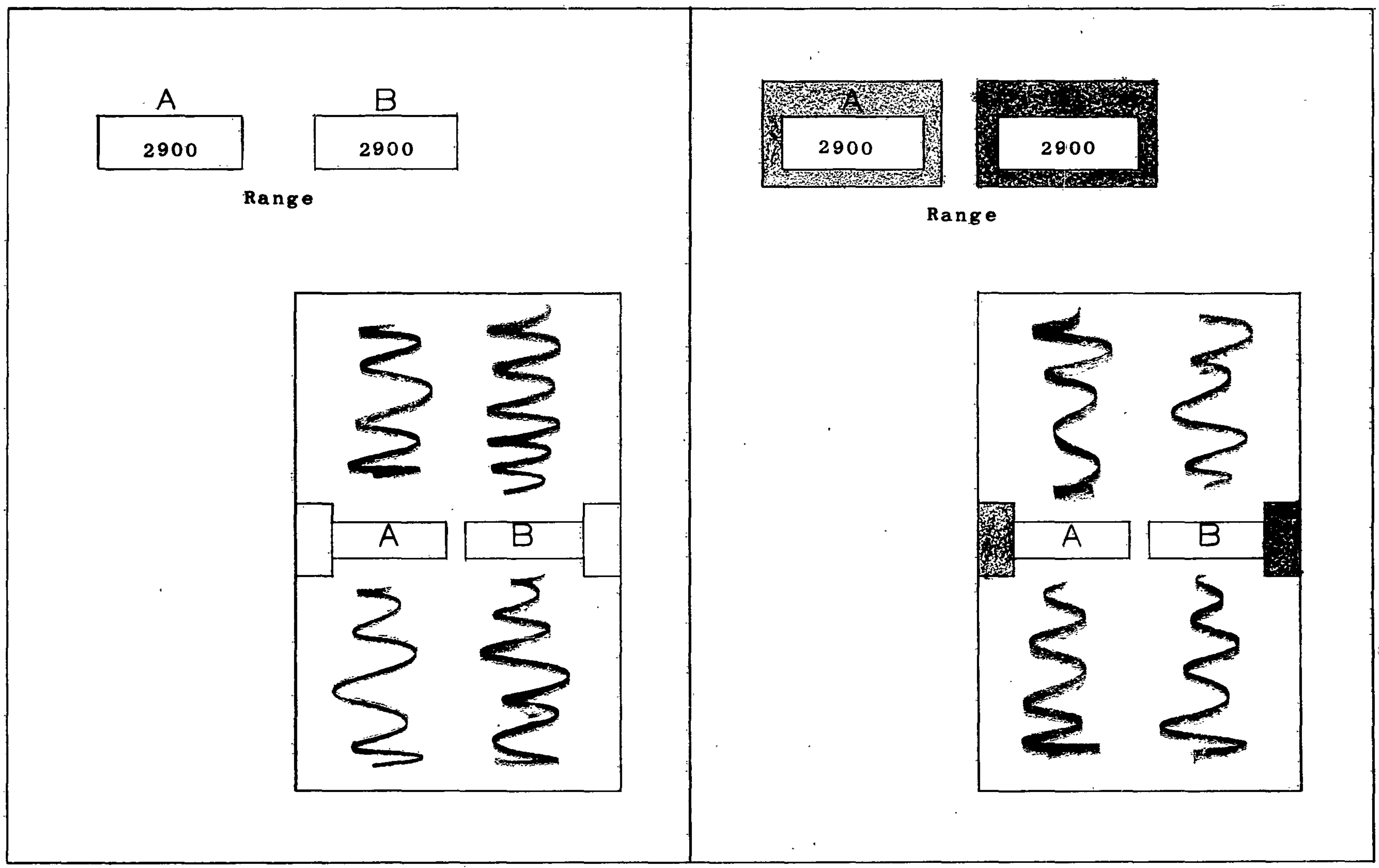

Figure 3. The current JULIE display and a proposed modification by color coding.

actually, the colors on the JULIE display would be painted under the thumb slides, which should be clear plastic. We recognize that red lighting vitiates the use of color codes, but this is wholly true only if the red is "completely red," i.e., having a spectral energy distribution completely in the red region of the spectrum, or well above 6000 Angstrom units. (This is true too if the maximum amount of night vision is to be preserved by the use of red illumination.) In the few red lighting systems briefly examined, this did not appear to be the case, i.e., some color coding may easily be possible (and night vision is <u>not</u> being preserved as well as it could be: for that matter, we know of no good reason why equipment operators on the flight deck, or ordnance men, need to preserve night vision).

As another example, it was startling to find that while most sonobuoys are to some extent color-coded and have their identifying numbers clearly stenciled in large numbers on their sides, neither the colors nor the numbers are visible when they are vertically stored in the ready racks with just their tails visible. True, small (though apparently different) numbers are stenciled on the tails, but these are typically too small, oriented in random directions, and contrast extremely poorly with their background. In an observed flight in which it took the ordnance men many minutes to load the six launching chutes according to instructions from the TACCO, sonobuoy identification was finally made by reading the handwritten symbols on the dirty little slips of blue paper wired to each sonobuoy tail. This is, of course, a ridiculous situation, even more aggravated by the fact that during MAD operation the light above the rack must be turned off. There are probably several simple coding solutions to this problem.

With regard to equipment in general there is no doubt that the concern expressed by many with respect to the effectiveness of

fixed wing ASW is, to a significant extent, a product of the known fact that some ASW equipment is grossly unreliable. If 2 1/2 hours was not routinely spent checking out the ASW equipment immediately prior to each patrol or exercise, the picture would be even worse. Some things cannot, of course, be checked out even in 2 1/2 hours, and some not at all. Sonobuoys fail to operate with fair regularity when needed, PDC launchers sometimes don't launch (so the next time around the PDCs are thrown by hand from the waist-hatch), and almost unbelievably, from 1/4 to 1/3 PDCs fail to explode!* We deplore this last figure, not only because of the expense involved in "trying again," or because it has a <u>very</u> direct bearing on the effectiveness of fixed wing ASW, but also because it can be expected to create, if it hasn't already, a morale problem.

Finally with regard to hardware in general some maintenance problems appear to be ignored, perhaps with justification if sufficient maintenance personnel, or time, are not available. A tape recorder which "didn't work last time," and "doesn't work this time either" is precisely as valuable as no tape recorder. Yet without a tape of ASW communications during an exercise the primary purpose of exercise analysis by ASCAC is to a considerable extent defeated.

The Problem Of Ambient Noise

The consequences of working in high ambient noise are numerous. Over short periods temporary deafness results. Over prolonged periods partial permanent deafness can result. Of more immediate concern, however, is the effect upon verbal communications during flight and the usual solution is to have all crew members wear ear defenders fitted with earphones and microphones.

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*We are reminded of the fact that in 1950 1/3 of the U.S. Navy electronic equipment was inoperative (11). It would be interesting to know what the figure is today.

The problem associated with ear defenders is that some crew members, knowing that they will not be communicated with for considerable periods, remove their defenders--presumably the defenders are more uncomfortable than the noise. Experimental work done by the U.S. Marine Corps with the HR2S-1 helicopter (9) showed that after flights lasting 1 1/4 hours, marines not wearing defenders had a hearing loss in the speech range from 18 to 22 decibels, with recovery to normal taking from 26 to 32 hours. In the case of FAW-14 aircraft we infer that when operators remove their defenders they will be partially deaf after replacing them. The inevitable consequence is that they will find ICS communications less intelligible and the probability of error is therefore increased. It should be mandatory that all crew members wear defenders at all times during flight. Certainly there are more comfortable defenders than those in use.

Intercom Equipment

With respect to ICS equipment it will probably be agreed that fidelity in transmission of spoken messages is mandatory. This implies that ear defenders, microphones and earphones all be of top quality and proper fit. Unfortunately, such does not appear to be the case as a number of different types are in use. If any one set is superior to the others, it should be the only type used. If equipment is available which is superior still (as we believe there is), then it should be in use.

The accompanying figure (Figure 4) shows the considerable differences between four types of ear defenders in terms of the degree to which they attenuate sound. It can be seen that over a considerable range the Willson is superior to the other three. To the best of our knowledge FAW 14 does not have a Willson. A study should be undertaken to determine the most suitable equipment

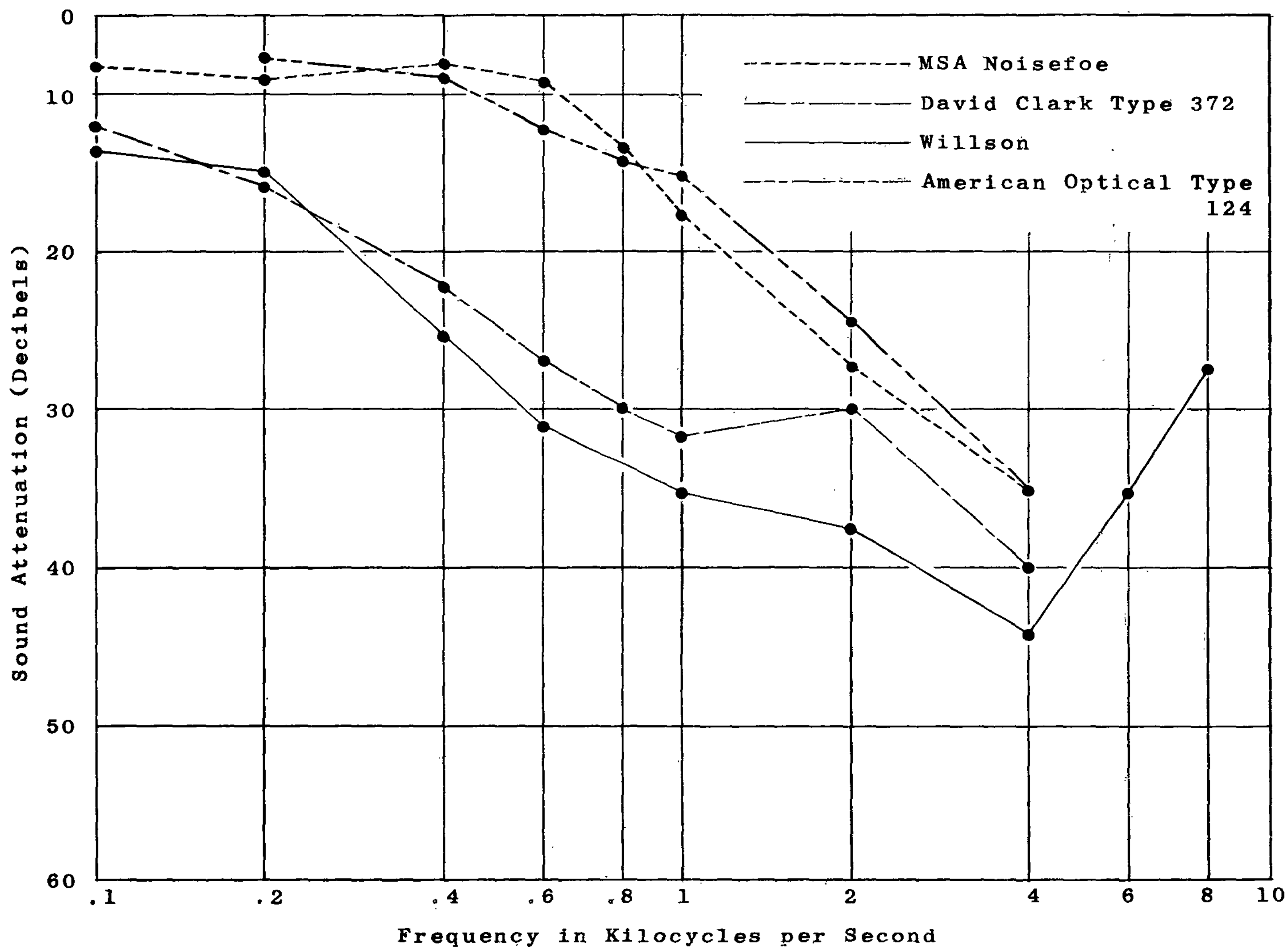


Figure 4. Sound attenuation characteristics of 4 ear defenders.

available. In passing we should note the work of Zwislocki (14) on earplugs. He has demonstrated "that the RD earplugs equipped with 9C earphones reduce the masking effect of an ambient white noise by nearly 45 db."

ASCAC

ASCAC has two functions. One is analysis of SODATRANS data, while the other is analysis of logs and tapes accumulated by each aircraft during an ASW exercise involving a submarine. As stated in the first paragraph of these notes, improvement in performance can be expected only when feedback is provided concerning errors in performance (and not always then if there is no motive for improvement). ASCAC is the sole agency for providing this feedback and it follows that anything that can be done to bolster ASCAC capability should be done. Some of these things follow.

The paper (log) work is voluminous--log-keeping is detested by most crew members (most of whom don't have a writing surface)--logs are frequently in error, and ASCAC analysis may take, largely because of such errors, as long as the actual exercise. It appears to us that one sensible solution would be to have a 7-channel tape recorder* mounted in the aircraft during each ASW exercise; an appropriate recorder would cost somewhat less than two routine patrols by a single aircraft. It should be pointed out that the number of recorders need not equal the number of aircraft--three or four should suffice. These recorders should "belong" to ASCAC, which would be given the necessary facilities for maintaining them, and should be installed and removed from the aircraft by ASCAC personnel just prior to and immediately after each ASW exercise flight. (We believe that this should be the case, too, with the

*The channels could be used in several combinations, e.g., 4 for JEZEBEL, 1 for ASW intercom, 1 for JULIE, 1 for MAD.

2-channel recorders now in use.) Some logs would still be kept, of course, e.g., some operators find their log useful in identifying the various sonobuoys dropped, but the major demands for log-keeping would be eliminated and the necessary flight data gathered much more accurately.

This "tape" proposal is not, of course, new, but the following modification may be. We believe that given appropriate equipment ASCAC could tune in on the ICS transmissions of any FAW-14 aircraft during an ASW exercise. The need for security might involve scrambling devices, or the equivalent, but only one multichannel recorder (or several single channel recorders) would be needed in ASCAC. There would be an auxiliary advantage. Knowing that all ICS might be monitored by those ashore, including rather senior persons, it seems highly probable that circuit discipline would improve.

Failing the adoption of a "tape" solution to the paper problem, we are of the opinion that a detailed analysis of the paper work involved in log-keeping could result in proposals which would reduce the volume (but not the necessary information) by from 1/4 to 1/3.

The next point in regard to ASCAC is that its analytic operation, as important as it is, is only vaguely understood by many flying personnel. Somewhere in the training programs of both officers and enlisted men the functions of ASCAC should be outlined, and if possible, demonstrated. Assuming that logs will continue to be kept, considerable emphasis should be made concerning the need for accuracy and neatness in keeping them. Finally, we believe that it would be very beneficial for both ASCAC and TACCOs if each TACCO, soon after his course was over, spent enough time in ASCAC to observe the complete analysis of at least two ASW exercises.

With regard to ASCAC analyses, it seems improbable that one

person will be responsible for all analyses. Such being the case it is important that there be a high degree of agreement between different persons undertaking ASCAC analyses. It is also important that each analyzer is consistent in his own analyses. The degree of inter-analyzer agreement and analyzer consistency could be determined by a rather brief experiment.

A final and most important point with respect to ASCAC, one which would be difficult to over-emphasize, concerns the manner in which completed ASCAC analyses are utilized. The whole purpose of an ASW exercise is largely vitiated if the feedback to the crews is not accurate and thorough. Such being the case the analyses should be done by very experienced personnel and the debrief and flight-reconstruction sessions should be conducted by the person who made the analysis. It is just not good enough to hand a sheaf of papers to a pilot and say "This is how your crew did yesterday." To this end there should be a room set aside expressly for the purpose of ASCAC debriefings. It should be equipped with an overhead projector, screen, blackboard, tape recorder (for playbacks only), and a large vertical plotting board on which the appropriate tracks are plotted as the debriefing progresses. In addition, in order to enhance motivation there should be clearly displayed a record of the ASCAC performance score of each crew for each ASW exercise undertaken.

Training

Unlike many operational wings, particularly in wartime, FAW 14 has a heavy training responsibility: each year some 300 officers and 1,100 enlisted men are exposed to courses given by VP-31. The mission of VP-31 squadron is defined as one "of providing VP squadrons with a continuous pipeline flow of operationally trained flight and maintenance personnel in order to maintain a maximum level

of air combat readiness in the ASW patrol forces."

When one considers the immense financial output represented by the wing aircraft, and the fact that over the next 10 years the cost of operating FAW 14 will be approximately 1/3 of a billion dollars, the facilities available to VP-31 for carrying out its mission can only be described as miserly. We must presume that the financial outlay for these facilities reflects the degree of importance attached to ground-training by those disbursing funds--overcrowded administrative offices, shabby lecture rooms continually blasted by aircraft noises, scrounged and very make-shift equipment, not even enough typewriters for those learning Morse Code! At the same time the instructional staff appears to be knowledgeable, well motivated, and acutely aware of the importance of their mission.

At this time we are able to discuss training in the most general terms only. As a guiding philosophy we believe that when a TACCO (or JEZEBEL operator, or a JULIE operator, or any crew member) has reached the point in training where teams are formed for exercises in the Weapon Systems Trainers, <u>each crew member should already be truly competent at his specific task of operating (and communicating) properly</u>.

The Weapon Systems Trainers are to teach <u>teamwork</u>, not to teach basic individual skills. If a TACCO aborts an exercise so that a new beginning must be made, <u>he</u> may be getting necessary instruction, but the other team members are not.

Similarly, before exercises are undertaken with real targets, <u>each crew member should already be a truly competent member of a Weapon Systems Trainer team</u>.

In contrast, the prevailing situation, as we see it, is that basic individual ground-training is insufficient to the point where it steals valuable team time in the trainers, and trainer-training

is insufficient to the point where it steals valuable time from airborne exercises with actual targets. Our observations have led us to conclude that the basic training of TACCOs in particular should be critically examined with the aim of finding ways in which the rather difficult subject material can be either simplified or learned more thoroughly. This does not necessarily imply that a longer training period is needed for TACCOs (though the course at FAETUPAC seems extraordinarily brief in view of the key position of the TACCO), but it does imply the possibility of one which is better suited to the situation.

With regard to "better-suited" teaching programs, a case in point is the teaching of Morse Code by VP-31. The current teaching technique is similar to that used by the U.S. Army a number of years ago. Using this older technique, it took from 35 to 40 hours to bring students to the point where they could receive 5 words a minute, and an average of 15% failed to meet this criterion. In 1945 the Code-Voice teaching technique was developed. Using the Code-Voice technique, 5 words per minute could be received after only 27 hours of instruction, with about 4% failures (6).

How Good are Selection and Training?

Although both VP-31 and FAETUPAC graduate students on a "go-no go" basis, each has kept course achievement grades on those who have passed through the many courses of instruction given. In addition, VP-31 has kept records of the number of persons passing and failing each examination question asked.

These available records suggest that with a research effort it would be possible to:

(1) determine what relation there is between examination scores in the training schools and individual performance during

operational duty (available from ASCAC analyses),

(2) determine what relation there is between GCT and other test scores of those personnel who attend the courses of instruction given, and grades achieved in these courses, and

(3) construct standardized performance tests which will truly differentiate between individual personnel for purposes of promotion, etc.

If, with respect to (1) above, a very low, or zero, relation were found, then there would be very serious doubt that the students were absorbing, to an adequate degree, the instruction given. On the other hand, a marked relation would suggest that the courses were indeed performing the service intended. In other words, the available data make it possible to evaluate the effectiveness of the current training programs, which should be done, of course, before any detailed examination is considered.

If, with respect to both (1) and (2), a marked relation were found, then the possibility would exist of predicting operational performance well in advance of arrival of personnel at the training schools, and consequently of laying down more satisfactory criteria of acceptance/rejection than exist at present.

Finally, truly standardized tests would be invaluable at the end of the training period, and also for identifying those in need of refresher courses.

Use of the Weapon Systems Trainers

With respect to the Weapon Systems Trainers, we are of the opinion that they might be used to far better advantage. To begin with, we must repeat that when teams are formed to work in the trainers, <u>each crew member should already be truly competent at</u>

operating his specific equipment (and communicating) properly.

Concerning instructional staff for the trainers, VP-31 is hoping to have, in the near future, up to seven highly-qualified officers and several well-experienced POs as a permanent instructional crew. The NCOs will directly oversee the crews in training. This is as it should be. We favor an even smaller crew of true experts, if possible, as the more instructors, the more variability in instruction, and consequently the more variability in procedures when operational. The aim should be as much operational consistency, throughout ASW FAWs as is feasible.

The next point is with respect to the actual exercises undertaken in the trainers. The first 24 of the 40 hours allotted each crew for trainer time while in VP-31 are devoted to emphasis upon particular pieces of equipment, e.g., JEZEBEL, JULIE, MAD. Each of the last 4 periods (4 hours each) is described as "a complete ASW problem from preflight brief through search, detection, localization and on to attack. All installed ASW search, detection, and localization equipment is used, keeping the problem as realistic as possible."

In our view, each of these last 4 periods (problems), graded in difficulty from easy to more difficult, should be considered as a formal examination, and the team should not be allowed to proceed to a more difficult problem until a passing grade had been achieved on the one preceding. Failure to achieve a passing grade should automatically involve a repeat examination on another problem known to be of the same level of difficulty, and on still another, until passed. Extensive debriefing after a poor team performance, followed by a more difficult problem in the next period will not produce as efficient teams as the proposal made here. Further with regard to this proposal is the possibility that some teams will

require considerably more than 40 hours in the trainer. This may not be correct. With respect to the first 24 hours, we are of the opinion that they could possibly be somewhat shorter. The 12 hours of "JULIE" exercise shown in the syllabus appear to be extravagant if the TACCO and the JULIE operators each know their individual tasks thoroughly before embarking on trainer exercises.

The notion of using the trainers for formal examination purposes implies that the performance of each team member and that of the team as a whole should be quantified, i.e., scored. This in turn implies a series of problems, graded in terms of <u>known</u> difficulty, with several of equivalent difficulty in each grade. This in turn implies a detailed study to determine various levels of difficulty, the determination of passing marks, and the preparation of detailed scoring sheets to be filled in by the instructors <u>during</u> the time a team is performing. It also involves some analysis of logs kept by team members. Other equipment needed would include a repeater of the TACCO's display in the instructor's compartment; we understand that these may soon be available.

In addition to the advantage that operational teams should be able to qualify much sooner than they do, such a "library" of problems would:

(1) pinpoint specific difficulties (which should be fed back to the instructional units concerned)

(2) provide <u>meaningful</u> "check-outs" of operational crews and those on refresher courses, and

(3) provide additional motivation by generating informal (and on occasion, formal) team competition.

Finally, with respect to the trainers, the audio noise level during an exercise should be the same as that experienced in flight.

It is understandably kept lower at present, but if intercom problems and problems of auditory target detection are to be located during training, they can be best revealed in the same audio environment as that which obtains operationally. Further with respect to intercommunications, we are of the opinion that both ICS procedures and circuit discipline are, on the average, extremely poor. With some surprise we learn that they are not formally taught in the instructional schools -- the 1-hour period allotted by VP-31 to "ASW Logs, Records, and ICS Procedures" is certainly insufficient--but rather are "picked up" during other courses of instruction. Some formal instruction seems rather badly needed.

Training Aids

Buchanan (3) quotes Captain O. F. A. Gollings, Royal Marines, as stating that "the contribution of the instructional film to the War II effort in accelerating the training of large numbers of service personnel and the generally increased efficiency of that training has been indisputably proven." While we know of no studies which have demonstrated unequivocally that training films result in superior training we share with the great majority the opinion that such is the case.

FAETUPAC has a number of training films (obtained from the RCAF!) devoted to some pieces of hardware, e.g., JULIE, and instructional personnel value them highly. However, there are no films for other pieces of hardware, e.g., JEZEBEL. If films are of value, as they certainly seem to be, then they should be available in sufficient number to cover every phase of fixed wing ASW. In addition, there should be at least one film showing in clear and correct detail the detection, localization and killing of a submarine.

Problems With Respect To Personnel

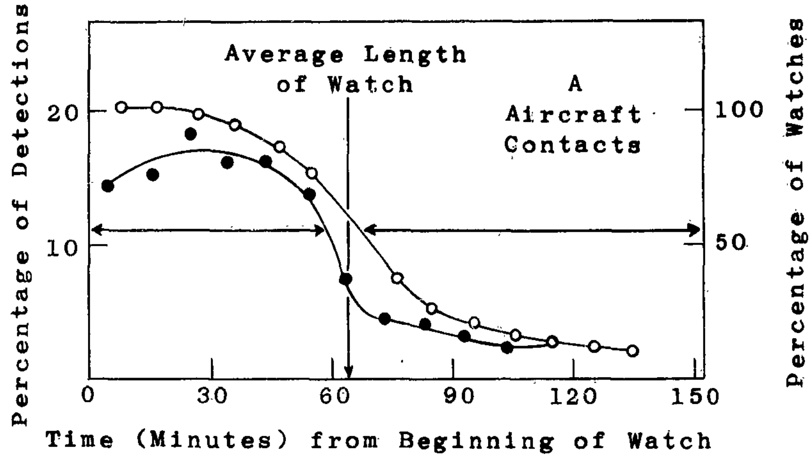
The problem of concern here is time on watch.

There is no doubt that the task we are dealing with here, combining as it does continuous monitoring for long periods of time of poorly designed display having inputs from marginally sensitive sensors, is not a task which humans typically perform well.

Humans cannot stay continually alert. The first operational data to demonstrate this fact were collected during War II by the RAF Coastal Command (1), and they are shown in Figure 5. Consider the top figure, which is concerned with detections by airborne radar of other aircraft. The top curve in this figure shows how the lengths of radar watches were distributed. It indicates that nearly all watches lasted 30 minutes, about half of them lasted an hour, and some lasted 2 hours or longer. The bottom curve in this figure shows the percentage of aircraft detections in relation to the length of watch. The point to be noted is that the longer the watch the fewer the detections.

The bottom figure shows the same general story with respect to detections of submarines. In fact, this particular study flatly stated that if all radar watches had lasted just half an hour, 50 per cent more submarines would have been detected.

This finding sparked a great deal of laboratory research which is still going on--over 200 investigators in at least eight countries. The phenomenon of deteriorating monitoring performance is known to be, beyond question, a very real one, and in situations such as operational ASW flights, a most dangerous one. It can be taken for granted that during long patrol flights the performance of the radar, MAD, and ECM operators, and visual lookouts,



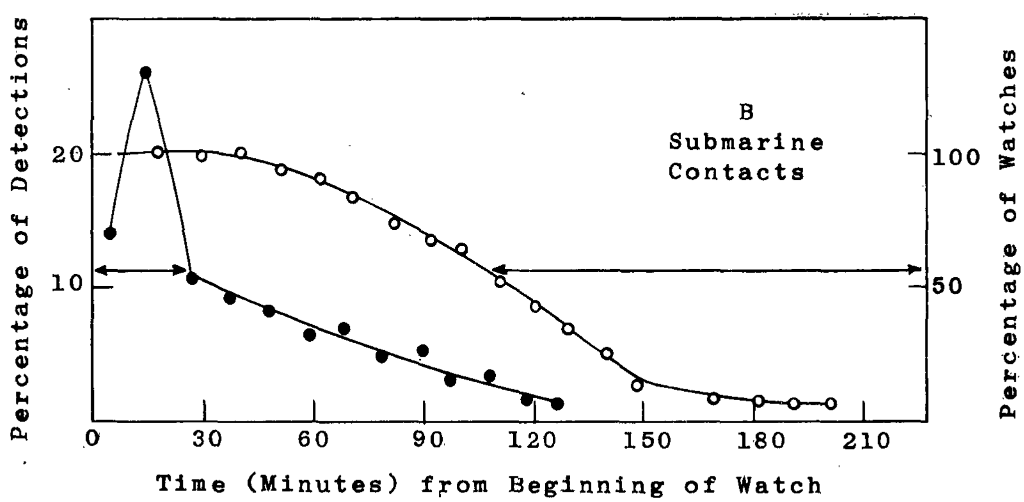


Figure 5. Cumulative percentages of lengths of radar watches (right ordinates) and percentages of aircraft and submarine detections (left ordinates) as a function of time on radar watch.

deteriorates in the manner shown in Figure 5. In other words, after something less than an hour on patrol, searching for submarines, the detection capability of a P5M or P2V is about half what it was soon after the beginning of the flight.

A fair bit of research has been aimed at finding techniques which will eliminate or at least lessen the deterioration in watch-standing performance and several techniques, each of which involves special equipment, are now known. One effective and very simple technique, which involves no special equipment however, is to have operators change tasks every half-hour (8). We are therefore of the opinion that the probability of submarine detection by operational patrols (who do not <u>know</u> that a submarine is in the area) will be considerably enhanced if the operators responsible for making detections alternate between equipments about every half-hour.

The possibility of employing other techniques--use of artificial signals, knowledge of results, etc.--can be stated only after a more thorough study of the airborne operations in question.

In Conclusion

These brief notes are intended simply to point out some of the problems with respect to the combination of operators and equipment. If the recommendations made above and outlined immediately following were brought into effect, there would doubtless be <u>some</u> improvement in efficiency, but two fundamental problems would probably limit the "some" improvement to "still not enough." One of these problems concerns equipment: the sensors, in terms of both discriminitive ability and reliability, are inadequate. The other problem is that, most unfortunately, the Navy does not recognize fixed wing ASW as a specialty. The consequence is that many of the personnel involved are doing a task in which, in personal terms, there is no

"real future." They are denied the opportunity of becoming true professionals in the best sense of the phrase. On the other hand the recommendations, if followed, should have a direct and beneficial effect upon the degree to which human factors problems are considered in the designs of future systems.

Recommendations

The following recommendations are classified as (1) recommendations which could be brought into effect by the Naval units involved and (2) recommendations for studies by a research agency.

Recommendations Which Could be Brought Into Effect by the Naval Units Involved

1. During ASW exercises involving practice with a single display, e.g., MAD, the exercises should be designed in such a way that operator expectancy of the presence of a target is not a contributing factor to his detection performance.

2. JULIE cursors and range readouts should be color-coded.

3. All crew members should wear ear defenders at all times during flight.

4. On each ASW exercise, a 7-channel tape recorder should be installed in the aircraft and record all ICS and recordable signal returns. Consideration should be given to the alternative possibility of recording all pertinent data in ASCAC, via radio link from air to shore.

5. All flying personnel should be made familiar, during training, with the functions of ASCAC. All TACCOs should spend some time observing ASCAC analyses.

6. ASCAC analyses should be more formalized than at present, with debrief and reconstruction sessions conducted by the personnel who conducted the analysis in an area specifically equipped for this

purpose.

7. The system of teaching Morse Code should be changed to one which has been proven superior.

8. Instructional crews in the Weapon Systems Trainers should be as small as is compatible with the routine nature of the job, and be composed of the most experienced personnel available.

9. The audio noise level in the Weapon Systems Trainers should be the same as that experienced in flight.

10. ICS procedure and circuit discipline should be formally taught.

11. During long periods of patrol aimed at the detection of submarines, personnel responsible for detections should alternate between stations every half-hour.

<u>Recommendations for Studies by a Research Agency</u>

1. Experimental work should be undertaken to determine the optimum brightness of the radar displays in the P5M and P2V.

2. A study should be made to determine an effective method of restricting ambient illumination at the radar displays to a tolerable level.

3. Illumination within the JEZEBEL display should be studied experimentally to determine the optimum level.

4. The correct viewing angle for JEZEBEL traces should be determined experimentally and a simple aid devised to indicate to the operator just where he should view from.

5. Experimental work should be undertaken with the MAD display to determine optimum paper speed and gain settings.

6. An appropriate method of coding sonobuoys should be determined.

7. A study should be performed to determine the most suitable intercom equipment available.

8. If multichannel tape recorders are not made available, a detailed study should be made of airborne logging procedures with a view to decreasing the amount of paper work involved.

9. A study should be undertaken to determine the degree of agreement between analyzers of ASCAC data, and also to determine how consistent ASCAC analyzers are.

10. A detailed study should be made of the task of the TACCO, including the course of instruction given to TACCOs, with the aim of bringing them to an acceptable level of competence considerably sooner than appears to be the case at present.

11. The relation between examination scores in the courses of instruction and performance during operational duty should be determined.

12. The relation should be determined between GCT and other test scores of those personnel who attend the ASW courses of instruction, and grades achieved in these courses.

13. Standardized performance tests should be constructed for each of the ASW courses given.

14. The problems given to crews in the Weapon Systems Trainers should be analyzed in detail in order that a series of problems, varying in known degrees of difficulty, can be used as team examinations. These examination problems, at least four in number, should be successfully passed according to a detailed and comprehensive scoring system, before team members become operational.

15. More training films are needed in FAETUPAC.

16. A study should be made to determine the possibility of employing known techniques to maintain operator alertness during long periods of patrol aimed at detecting submarines.

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